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PHYSICS.—*The thermodynamic characteristic for all bodies.*[1] A. PRESS. (Communicated by E. W. WOOLARD.)

Starting with the fundamental energy equation of thermodynamics we have

$$dQ = dU + pdv = dU + dW \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In general, of course, dU, representing the internal energy, is a perfect differential—not so pdv. To integrate (1) we require to turn the whole equation into a perfect differential. The common mathematical device of multiplying with a known integrating factor can therefore be resorted to. For generality let this integrating factor be

$$\mu = f(v, \theta) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The energy equation (1) then takes the form

$$\mu\, dQ = \mu \frac{\partial U}{\partial \theta} d\theta + \mu \left(p + \frac{\partial U}{\partial v}\right) dv \ldots\ldots\ldots\ldots (3)$$

The usual condition that now needs to be satisfied for a perfect differential is that we have

$$\frac{\partial}{\partial v}\left(\mu \frac{\partial U}{\partial \theta}\right) = \frac{\partial}{\partial \theta}\left\{\mu \left(p + \frac{\partial U}{\partial v}\right)\right\} \ldots\ldots\ldots\ldots (4)$$

which reduces to

$$\frac{\partial U}{\partial \theta} \cdot \frac{\partial \mu}{\partial v} - \frac{\partial U}{\partial v} \cdot \frac{\partial \mu}{\partial \theta} = \frac{\partial}{\partial \theta}(\mu\, p) \ldots\ldots\ldots\ldots (5)$$

[1] Received March 20, 1928.

It is to be remembered that thermodynamically speaking equation (5) applies to all bodies. No matter what the U may be, as a function of v and θ for a particular body, it nevertheless is true that (5) obtains. Yet the whole of ordinary thermodynamics rests on the basis that the three variables, p, v and θ for example, are sufficient to specify a thermodynamic surface function. In the above, five variables

$$U, \mu, p, v, \theta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

occur. The question arises, can a surface characteristic function such as

$$p = F(v, \mu) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

be formed in view of (2), (thereby giving $p = F(v, \theta)$ if desired), that will satisfy (5) and obtain for all bodies. Equation (7) therefore needs to be a very comprehensive, that is, functional type.

Let us therefore postulate the following:

(*a*) That a function $\mu = f(v, \theta)$ exists which as an integrating factor will be common to all bodies characterized by the energy equation (1).

(*b*) That for any μ so taken, and a p given, a body can always be found that will enable U to be arbitrarily chosen, making U therefore an independent variable with respect to a given μ and p.

If then the above postulates are accepted, a solution of (5) can be found by the method of separation of variables.

Thus we can take as one independent variable

$$\chi = \frac{\partial}{\partial \theta} (\mu p) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

On the other hand for the same μ applying to all bodies we can introduce a further independent variable defined by the relation

$$Z = \frac{\partial U}{\partial \theta} \cdot \frac{\partial \mu}{\partial v} - \frac{\partial U}{\partial v} \cdot \frac{\partial \mu}{\partial \theta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

This should appear possible in view of postulate (*b*). We then have by (5) that

$$Z = \chi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

In an equation of the type of (10), or its equivalent (5), we are

therefore entitled to seek a "particular solution" by setting each side in turn equal to zero.[2] Thus for the right hand term we have

$$\frac{\partial}{\partial\theta}(\mu p) = 0;\ pV = \frac{1}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Where V is an arbitrary function of v arising as a "constant" of integration. This is a very simple relation for the thermodynamic characteristic for all bodies.

In fact if we wish to determine the integrating factor μ for any characteristic applying to a particular body, equation (11) indicates the method if the V-function is known. This will be exemplified.

An equation such as (11), or its equivalent

$$\frac{\partial U}{\partial\theta}\cdot\frac{\partial\mu}{\partial v} - \frac{\partial U}{\partial v}\cdot\frac{\partial\mu}{\partial\theta} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

has other important consequences, for we have that

$$\frac{\dfrac{\partial U}{\partial\theta}}{\dfrac{\partial U}{\partial v}} = \frac{\dfrac{\partial\mu}{\partial\theta}}{\dfrac{\partial\mu}{\partial v}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

showing that we must also have

$$\mu = \Phi(U) \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

The integrating factor is then a function of the internal energy U. For the perfect gas we would thus have

$$\mu = \frac{1}{\theta} = \Phi(U) \quad \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Of course having found the "particular solution" given by (11) we can attempt to find a more "complete solution." Let us then write

$$\mu = M\,\mu_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (15a)$$

where $M = \phi(U)\cdot\psi(v,\theta) + 1$

giving $\mu = \mu_0 + F(v,\theta)$ $\Big\}$ $\ldots\ldots\ldots\ldots$ (16)

and $\mu_0 = \Phi(U)$ $\ldots\ldots\ldots\ldots\ldots\ldots$ (14)

[2] Or to a constant. The latter alternative does not check with the requirements for an ideal gas.

Taking note of (12) and (15a) we have

$$\left.\begin{aligned}\left(\frac{\partial \mu}{\partial v}\right)_\theta &= M\left(\frac{\partial \mu_0}{\partial v}\right)_\theta + \mu_0\left(\frac{\partial M}{\partial v}\right)_\theta \\ \left(\frac{\partial \mu}{\partial \theta}\right)_v &= M\left(\frac{\partial \mu_0}{\partial \theta}\right)_v + \mu_0\left(\frac{\partial M}{\partial \theta}\right)_v \\ \frac{\partial}{\partial \theta}(\mu_0 p) &= M\frac{\partial}{\partial \theta}(\mu_0 p) + \mu_0 p\left(\frac{\partial M}{\partial \theta}\right)_v\end{aligned}\right\} \quad \ldots\ldots\ldots (17)$$

Substituting back it follows that

$$M\frac{\partial U}{\partial \theta}\cdot\frac{\partial \mu_0}{\partial v} - M\frac{\partial U}{\partial v}\cdot\frac{\partial \mu_0}{\partial \theta} - M\frac{\partial}{\partial \theta}(\mu_0 p)$$

$$+ \mu_0\left(\frac{\partial M}{\partial v}\right)_\theta\cdot\frac{\partial U}{\partial \theta} - \mu_0\left(\frac{\partial M}{\partial \theta}\right)_v\cdot\frac{\partial U}{\partial v} = \mu_0 p\left(\frac{\partial M}{\partial \theta}\right)_v \quad \ldots\ldots (18)$$

The first line of (18) then vanishes because by (14) μ_0 is already the particular integrating factor. That is to say, (18) must reduce to the following

$$\frac{\partial U}{\partial \theta}\cdot\left(\frac{\partial M}{\partial v}\right)_\theta = \left(p + \frac{\partial U}{\partial v}\right)\left(\frac{\partial M}{\partial \theta}\right)_v \quad \ldots\ldots\ldots\ldots (19)$$

A simplification of (19) is in order because by definition in (16), M is assumed a function of v and θ so that

$$\frac{\left(\frac{\partial M}{\partial v}\right)_\theta}{\left(\frac{\partial M}{\partial \theta}\right)_v} = -\left(\frac{\partial \theta}{\partial v}\right)_M \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

That is to say, we can write (19) in the following manner

$$p + \frac{\partial U}{\partial v} = \left(-\frac{\partial \theta}{\partial v}\right)_M\cdot\frac{\partial U}{\partial \theta} \quad \ldots\ldots\ldots\ldots\ldots (21)$$

The function M then does exist, for thermodynamically speaking the latent heat function $p + \frac{\partial U}{\partial v} = l$ must be in some manner related to the specific heat at constant volume, $\frac{\partial U}{\partial \theta} = C_v$.

Applying the above to the equation of a perfect gas by way of example, let

$$pv = R\theta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

Then for the integrating factor μ_0 we can set according to equation (11) that

$$\frac{1}{\mu_0} = R\theta;\ \mu_0 = \frac{1}{R\theta} \ldots\ldots\ldots\ldots\ldots\ldots (23)$$

Again, knowing that for a perfect gas $\frac{\partial U}{\partial v}$ in (21) would be equal to zero we have

$$\frac{\partial U}{\partial v} = 0;\ \frac{\partial U}{\partial \theta} = C_v = \alpha \ldots\ldots\ldots\ldots\ldots\ldots (24)$$

Therefore by (21) and (22)

$$-\alpha \cdot \left(\frac{\partial \theta}{\partial v}\right)_M = \frac{R\theta}{v} \ldots\ldots\ldots\ldots\ldots\ldots (25)$$

The integral of (25) is consequently

$$\theta \cdot v^{\frac{R}{\alpha}} = f(M) \ldots\ldots\ldots\ldots\ldots\ldots (26)$$

and for the simplest form of $f(M) = M$ we have

$$\mu = \theta \cdot v^{\frac{R}{\alpha}} \cdot \frac{1}{R\theta} = \frac{1}{R} \cdot v^{\frac{R}{\alpha}} \ldots\ldots\ldots\ldots\ldots\ldots (27)$$

In other words a further integrating factor is a function of v only whereas the original one was $\mu = \frac{1}{\theta}$.

Multiplying the Energy Equation with the μ of (27) we have for an ideal gas in view of (24) and (22) that

$$R_\mu\, dQ = v^{\frac{R}{\alpha}} \cdot \frac{\partial U}{\partial \theta} \cdot d\theta + v^{\frac{R}{\alpha}} \cdot p \cdot dv$$

$$= v^{\frac{R}{\alpha}} \cdot \alpha \cdot d\theta + R\theta \cdot v^{\frac{R}{\alpha}-1} \cdot dv \ldots\ldots\ldots\ldots\ldots (28)$$

The latter is a perfect differential since we have

$$\frac{\partial}{\partial v}\left(\alpha\, v^{\frac{R}{\alpha}}\right) = \frac{\partial}{\partial \theta}\left(R\theta\, v^{\frac{R}{\alpha}-1}\right) \ldots\ldots\ldots\ldots\ldots\ldots (29)$$

Elsewhere I have shown that the particular integrating factor given by

$$\left.\begin{aligned} pV &= \frac{1}{\mu} \\ \text{with } \mu &= f(U) \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (30)$$

leads to a consideration of a new type of cycle analogous to that of Carnot. The new cycle comprises two adiabatics and two iso-U curves instead of two isothermals.

CRYSTALLOGRAPHY.—*The crystallography and optical properties of β-lactose.*[1] EDGAR T. WHERRY, Bureau of Chemistry and Soils.

Although the crystallographic features of ordinary α-lactose have been fully described, there appear to be no data on the β-form. In the study of the development of minute crystals of sugars in ice cream, the Bureau of Dairy Industry of the United States Department of Agriculture found it desirable to have means for distinguishing these two forms of lactose from one another as well as from sucrose, and the examination of the grains by the immersion method under the polarizing microscope seems well adapted to the purpose. Accordingly O. E. Williams of that Bureau prepared and turned over to the writer a sample of crystallized β-lactose, in order that its properties might be determined and contrasted with those of other sugars. The crystals were obtained by holding a concentrated lactose solution at a temperature of about 94°C. They were then washed several times with hot glycerol and hot ethanol. The melting point was found to be 252.4°C.; since the melting point given in the literature is 252.2°, their identity was thus confirmed.

The crystals, which range from 1 to 5 mm. in diameter, are transparent and colorless. They have a pronounced polar development, and the distribution of their faces show that they belong to the holoaxial-polar (sphenoidal) class of the monoclinic system. Measurements of 10 crystals were made on the two-circle goniometer, with the results presented in Table 1.

[1] Received March 19, 1928.

TABLE 1.—ANGLES OF β-LACTOSE

Monoclinic, holoaxial-polar; $a : b : c = 0.817 : 1 : 0.377$; $\mu = 88° 15'$

No., letter	Symbols		Description	Angles			
				Measured		Calculated	
	Goldschmidt	Miller		φ	ρ	φ	ρ
1. *c*	0	001	Prominent but distorted	80°–85°	1° 45′	90°00′	1°45′
2. *m*	∞	110	Dominant, reflecting well	50° 45′	90° 00′	50°45′	90°00′
3. *L*	−2 ∞	$2\bar{1}0$	Prominent, much curved	65°–75°	90° 00′	67°46′	90°00′
4. *X*	$-1-\frac{1}{2}$	$\bar{3}\bar{2}3$	Moderately curved	58°–60°	25°–27°	59°44′	26°29′

For the most part the faces are more or less rounded, but the angles could be measured with sufficient precision to make the second decimal place certain, so that the axial ratios are stated to the third place. The form having the most nearly perfect faces was taken as the positive unit prism, and used for orienting the crystals on the goniometer. The value of the acute monoclinic angle μ (often called β by American crystallographers, although this symbol more properly belongs to the obtuse angle) was then obtained by measuring the ρ angle of the principal terminal plane, which was taken as the basal pinacoid. To obtain the axial ratio *c* it was necessary to use measurements on a distinctly curved form, so that the value of this axis is especially uncertain. That form was taken to be a negative back pyramid, and the symbol for it which gave the most reasonable value for *c* was found by trial to be $(\bar{3}\bar{2}3)$. Figure 1 shows the habit, the plan at the top having been drawn with straight edges in the theoretical positions, the parallel-perspective elevation below with the edges in part curved as they are in reality.

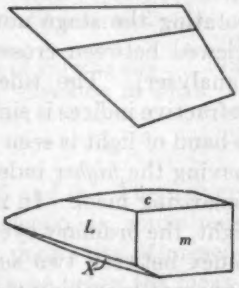


Fig. 1

When examined by the immersion method under the polarizing microscope, the substance appears in irregular fragments, showing between crossed nicols first to third order colors, and yielding on trial with successive liquids the refractive index values: $\alpha = 1.542$, $\beta = 1.572$, $\gamma = 1.585$. As the positions of the grains are random, means of these values are usually exhibited, although it is not difficult to find grains with the different index directions lying horizontally, so that matching with the corresponding liquids can be obtained. In convergent polarized light negative biaxial interference figures having a rather large axial angle, $2E = 120°$, are occasionally obtained, the

axial plane lying in the ortho-zone, and the acute bisectrix lying in angle μ about 30° from axis c. Table 2 shows these values, contrasted with those of α-lactose and sucrose.

TABLE 2.—OPTICAL CONSTANTS OF THREE SUGARS

Substance	α	β	γ	$2E$
α-lactose	1.517	1.553	1.555	33½°
β-lactose	1.542	1.572	1.585	120°
Sucrose	1.540	1.567	1.572	79°

The reason that the refractive indices of the β-lactose are so much higher than the corresponding ones of the α-form is that the former is anhydrous, whereas the latter is a monohydrate. The value of β given for α-lactose represents a redetermination, and accords with the small axial angle better than the value usually ascribed to this substance. In all three cases, however, β is less certain than are the other two indices, because of the random positions assumed by the grains.

For distinguishing these three sugars in practice the procedure given in Table 3 may be used. Oily immersion liquids of refractive indices 1.520, 1.540, 1.555, 1.570, and 1.585 are required. All observations should be made on grains brought to an extinction position by rotating the stage until the grain attains its maximum darkness as viewed between crossed nicols, and then removing the upper nicol (analyzer). The rule for ascertaining the relative values of the refractive indices is simply that on *raising* the microscope-tube slightly a band of light is seen to pass into that substance—crystal or liquid—having the *higher* index in the direction of the vibration plane of the polarizing nicol. In making such observations in white or yellowish light, the ordinary eye is unable to distinguish differences in refractive index between two substances in contact less than about $\pm$ 0.003; apparent matching means, then, that the index of crystal and liquid agree with this degree of approximation.

TABLE 3.—DIRECTIONS FOR DISTINGUISHING α-LACTOSE, β-LACTOSE, AND SUCROSE

Immerse in liquid 1.520. If the boundaries of numerous grains disappear, repeat with liquid 1.555; if this is also matched by a number of grains the substance is	α-lactose.
In case the refractive indices of the grains are all decidedly higher than the first liquid, try liquid 1.540. If this matches the lowest index of some grains, repeat with liquid 1.570; if some grains match this and none show a higher value, the substance is	sucrose.
If one refractive index on many grains proves to be distinctly higher than the last liquid tried, immerse next in liquid 1.585. If this matches the highest refractive index of any of the grains, the substance is	β-lactose.
Should none of these requirements be fulfilled, the substance under examination is neither lactose nor sucrose.	

GEOLOGY.—*A new locality for Fox Hills fossils in Colorado.*[1] J. HARLAN JOHNSON, Colorado School of Mines (Communicated by JOHN B. REESIDE, JR.).

In August, 1926, the writer discovered a new and rather prolific locality for Fox Hills fossils that seems worth recording because of the fine preservation and unusual variety of forms present. It is located in secs. 21 and 22, T. 11 N., R. 68 W., southeast of Round Butte and about 12 miles north of the town of Wellington in Larimer County, Colorado.

The fossils occur in a relatively thin zone at about the base of the Millikin sandstone member, as defined by Henderson.[2] The stratigraphic section at the locality is as follows:

SECTION OF PART OF THE FOX HILLS SANDSTONE IN SECS. 21 AND 22, T. 11 N., R. 68 W., LARIMER COUNTY, COLORADO.

Bed		Feet
8.	Sandstone, greenish yellow, massive though rather soft	25
7.	Sandstone, white, containing many small limonite concretions	9
6.	Sandstone, soft, massive, white with light brown streaks; some buff concretions near base	18
5.	Sandstone, hard, dark brown	1
4.	Sandstone soft, massive, white; contains irregularly scattered concretions as much as 4 feet in diameter	12
3.	Sandstone, soft, buff; contains brown concretions of varying size	15
2.	Shale, brown, sandy, with much concretionary limonite in small masses	4
1.	Shale, dark gray to black, slightly sandy	?

Most of the fossils collected came from beds 5 and 6. There were also, in bed 4 and bed 6, sandstone casts of pelecypods, sometimes showing remnants of the shell, but usually in a poor state of preservation. No fossils were noted in beds 1, 2, or those below the measured section. The best preserved specimens came from concretions in bed 4, though a number of well preserved fossils came from other concretions at the base of bed 6.

The fauna of the locality, as determined by John B. Reeside, Jr., of the U. S. Geological Survey, is as follows:

Pelecypoda: *Callista nebraskensis* Meek and Hayden, *Cardium speciosum* Meek and Hayden, *Gervillia subtortuosa* Meek and Hayden, *Mactra formosa* Meek and Hayden, *Modiola meeki* Evans and Shumard,

[1] Received March 13, 1928.

[2] JUNIUS HENDERSON. Colo. Geol. Surv. Bull. 19: 22. 1920.

Nucula larimerensis Reeside,[3] *N. weldensis* Reeside,[3] *Ostrea gillulyi* Reeside,[3] *Ostrea* sp.?, *Protocardia subquadrata* Evans and Shumard, *Pteria nebrascana* Evans and Shumard, *Teredo?* tubes, *Veniella humilis* Meek and Hayden.

Scaphopoda: *Dentalium gracile* Hall and Meek.

Gastropoda: *Anchura americana* Evans and Shumard, *Cylichna volvaria* Meek and Hayden, *Fasciolaria* (*Piestocheilus*) *scarboroughi* Meek and Hayden, *Fasciolaria* sp., *Fusus* (*Serrifusus*) *dakotensis* Meek and Hayden, *Fusus?* sp., *Gyrodes johnsoni* Reeside,[3] *Haminea subcylindrica* Meek and Hayden, *Lunatia occidentalis* Meek and Hayden, *L. subcrassa* Meek and Hayden, *Pyropsis bairdi* Meek and Hayden?, *Pyropsis* sp., *Trachytriton vinculum* Hall and Meek.

Cephalopoda: *Discoscaphites conradi* Morton.

Associated with the invertebrates were shark teeth, small vertebrae of fish, and silicified wood, in part showing the effects of attack by boring mollusks.

PALEONTOLOGY.—*New Cretaceous mollusks from Colorado and Utah.*[1] JOHN B. REESIDE, JR., U. S. Geological Survey.

This paper describes three species of pelecypods and a gastropod from the Fox Hills sandstone (Maestrichtian) of northeastern Colorado and a gastropod from the base of the Colorado group (lower Turonian) of Utah. The geographic location, stratigraphic position, and faunal association of the Fox Hills species are described above by Professor J. Harlan Johnson (pages 305–306).

Genus NUCULA Lamarck

Nucula larimerensis Reeside, n. sp.

Figures 7–9

A single specimen from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, is the basis of this species.

Shell moderately large, heavy; broadly subelliptical, moderately gibbous; proportion of length to height about as 5 to 3. Beaks blunt, subcentral. Lunule and escutcheon but little differentiated. Posterior margin narrowly rounded, anterior margin a little broader; basal margin gently convex, crenate inside. Dorsum declining with very slight convexity both before and behind the beaks; gross angle formed by the dorsum at the beak of the valve 130°.

[3] See pages 306–312 for description of these species.

[1] Published by permission of the Director of the U. S. Geological Survey. Received March 13, 1928.

Sculpture consists of fine, irregularly spaced concentric lines of growth; and very faint radial lines scarcely visible without the assistance of a hand lens, 2 per millimeter at the posterior margin and 3 in 2 millimeters at the anterior margin.

Hinge and other internal characters not seen.

Length, 35 millimeters; height, 22 millimeters; convexity of a valve, 8 millimeters.

This species is characterized by its medium size, broadly subelliptical outline, and very faint radial sculpture. No other species from the Western Interior is close enough to it to deserve comparison. *N. percrassa* Conrad[2] in the Ripley fauna of the Coastal Plain resembles *N. larimerensis* but the latter has much fainter radial sculpture, is less gibbous and more evenly subelliptical in outline, and has the beaks lower and placed farther forward. *N. larimerensis* also resembles *N. slackiana* Gabb[3] but has again much fainter radial sculpture, lower and more anteriorly placed beaks, and subelliptical outline.

The type is in the U. S. National Museum (Cat. No. 73454).

Nucula weldensis Reeside, n. sp.

Figures 16–18

Five specimens collected by Prof. Johnson from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, are the basis of this species.

Shell small, moderately heavy; subtrigonal, rather inflated; proportion of length to height about as 4 to 3. Beaks not very prominent, posterior, opisthogyrate. Lunule elongate, ill-defined, bordered by an indistinct angulation of the valve; escutcheon nearly smooth, cordate, of moderate size, sharply defined by an angular shoulder. Anterior and posterior margins rounded, basal margin semielliptic in outline, apparently smooth inside. Dorsum declining with moderate convexity anterior to the beaks and with slight concavity behind; gross angle formed by the dorsum at the beaks about 75°.

Sculpture of fine concentric growth lines and only the faintest suggestion here and there of radial sculpture.

Internal characters unknown in type. Cross-section of another specimen indicates a series of 20 teeth before the beak and one of 9 behind, diverging at an angle of 90°.

Length of type, 20 millimeters; height, 15 millimeters; convexity of a valve, 6 millimeters.

This species is characterized by small size; relatively high, subtrigonal, inflated shell; distinct escutcheon; smooth inner margins; and lack of radial

[2] T. A. CONRAD. *Observations on a group of Cretaceous fossil shells found in Tippah County, Miss.* Journ. Acad. Nat. Sci. Phila. (2) **3**: 327. *pl. 35, f. 4.* 1856; BRUCE WADE. *The fauna of the Ripley formation on Coon Creek, Tenn.* U. S. Geol. Surv. Prof. Paper **137**: 39. *pl. 8, f. 1–4.* 1926.

[3] W. M. GABB. *Descriptions of new species of American Tertiary and Cretaceous fossils.* Journ. Acad. Nat. Sci. Phila. (2) **4**: 397. *pl. 48, f. 37.* 1860; JULIA GARDNER. *Md. Geol. Surv. Rept., Upper Cret.*, p. 511. *pl. 19, f. 1–4.* 1916.

sculpture. It differs from the nearest forms of the Western Interior as follows: from *N. planimarginata* Meek and Hayden[4] in its smaller, stouter shell, higher subtrigonal outline, and lack of radial sculpture; from *N. cancellata* Meek and Hayden[5] in smaller size, higher subtrigonal shell, and lack of radial sculpture; from *N. coloradoensis* Stanton[6] in its larger, stouter shell and lack of radial sculpture; from an unnamed species in the Eagle sandstone of Montana in its lack of radial sculpture and smaller escutcheon. *N. weldensis* differs from similar species of the Coastal Plain as follows: from *N. stantoni* Stephenson[7] in its lack of radial sculpture, lesser height, stouter shell, and greater umbonal angle; from *N. amica* Gardner[8] in its lack of radial and strong, regular concentric sculpture; from *N. microconcentrica* Wade[9] in its subtrigonal form.

The type is in the U. S. National Museum (Cat. No. 73455); four paratypes are at the Colorado School of Mines, Golden, Colorado.

Genus OSTREA Linnaeus

Ostrea gillulyi Reeside, n. sp.

Figures 1–6, 10, 11

This species is represented by 6 individuals from 6 localities and a somewhat doubtful lot of 10 specimens from a seventh locality.

Shell of medium size, subovate to subtriangular, more or less arcuate. Shell thin in most specimens, moderately thick in some. Beaks narrow to pointed, slightly twisted, and turned posteriorly. Left valve swollen, rather evenly rounded; right valve flat to slightly concave, fitting within the margins of the left valve.

Hinge high, triangular, sharply inclined posteriorly. Ligament area crossed by fine growth lines and in the right valve by fine longitudinal lines also; groove well-defined, deep. Margins of right valve near the hinge coarsely dentate; of the left valve pitted to correspond with the denticles of the right valve. Muscle scar large, oval, situated toward the middle posterior of the valves. Margins of the lower part of both valves smooth.

Surface of left valve covered by irregular, rounded radial ribs, 2 to 4 millimeters wide, which bifurcate and are variable in height; and by sharp concentric lamellae. Surface of right valve with sharp concentric lamellae and obscure, irregular radial ribs or striae.

The height of the type is 75 millimeters; length, 40 millimeters; convexity of the left valve, 15 millimeters.

[4] F. B. MEEK. *Invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country.* Rept. U. S. Geol. Surv. Terr. 9: 101. *pl. 15, f. 8; pl. 28, f. 16.* 1876.

[5] F. B. MEEK. *Op. cit.*, p. 102. *pl. 28, f. 13.*

[6] T. W. STANTON. *The Colorado group and its invertebrate fauna.* U. S. Geol. Surv. Bull. 106: 94. *pl. 21, f. 9.* 1893.

[7] L. W. STEPHENSON. *Cretaceous formations of North Carolina.* Rept. N. Car. Geol. Econ. Surv. 5(1): 79. *pl. 11, f. 1–6.* 1923.

[8] JULIA GARDNER. *Op. cit.*, p. 514. *pl. 19, f. 5–6.*

[9] BRUCE WADE. *Op. cit.*, p. 40. *pl. 8, f. 7–8.*

This species is characterized by its strong radial sculpture, somewhat arcuate form, and its size. No species now known in the Western Interior is very close to it. In the Coastal Plain *O. tecticosta* Gabb[10] is similar but seems a consistently smaller, less arcuate, and more coarsely ribbed shell. Some Tertiary species also are similar to *O. gillulyi* but hardly enter into consideration here.

The type specimen (U. S. Nat. Mus. Cat. No. 73457) was collected by James Gilluly from the Fox Hills sandstone in the NW 1/4 sec. 7, T. 9 N., R. 67 W., Weld County, Colorado. Other specimens (U. S. Nat. Mus. Cat. No. 73456) from the Fox Hills of Colorado were collected by Prof. Johnson in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County. It is also represented in a collection made by V. H. Barnett from the top of the Lewis shale in the SW 1/4 sec. 34, T. 34 N., R. 77 W., Converse County, Wyoming; in a collection made by C. E. Dobbin from the lower part of the Lewis shale in NW 1/4 sec. 8, T. 21 N., R. 78 W., Carbon County, Wyoming. A collection made by T. W. Stanton from the Mesaverde formation at James Lake, Laramie Plains, Albany County, Wyoming, contains a number of specimens of an oyster that appears to be this species, though all the individuals are small and none are especially well preserved. The range of *O. gillulyi* would appear to be through the upper half of the Montana group.

Genus GYRODES Conrad

Gyrodes johnsoni Reeside, n. sp.

Figures 12–15

Three specimens from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, are the basis of this species.

Shell small for the genus, very much depressed, approaching a thick disk in general form. Volutions about 3 in number, the outer one constituting perhaps three-fourths of the bulk of the shell; well rounded in cross-section, showing neither shoulder nor umbilical carina. Surface of the shell in part preserved in the type and showing only lines of growth parallel to the aperture. Suture impressed. Aperture obliquely ovate; outer lip thin, sharp; inner lip thin, nearly straight. Umbilicus deep, open.

Maximum diameter of shell, 21 millimeters; altitude, 14 millimeters.

This species is distinguished from most species of *Gyrodes* by the lack of shoulder and umbilical carination, from others by the great depression of the whorls. *G. petrosa* Morton[11] and *G. depressa* Meek[12] are perhaps the nearest species but both have an umbilical carina and are relatively higher shells.

[10] W. M. GABB. *Op. cit.*, p. 403. *pl. 68, f. 47–48;* L. W. STEPHENSON. *Op. cit.*, p. 143. *pl. 33, f. 1–9.*

[11] STUART WELLER. *Cretaceous paleontology of New Jersey.* N. J. Geol. Surv., Pal. ser. 4: 689. *pl. 77, f. 13–18.* 1907.

[12] T. W. STANTON. *Op. cit.*, p. 135, *pl. 29, f. 11–14.*

This type is in the U. S. National Museum (Cat. No. 73458), and two paratypes are at the Colorado School of Mines, Golden, Colorado.

Genus ANCHURA Conrad

Anchura? forresteri Reeside, n. sp.

Figure 19

The scar of attachment of a large lower valve of *Exogyra olisiponensis* Sharpe var. *oxyntas* Coquand, from the basal part of the beds of Colorado age at Black Bluff, Utah, constitutes a fairly sharp mould of a gastropod not at present known by any other specimen.

Parts of three whorls and the exterior of much of the wing-like extension of the outer lip are shown. The species is high-spired, the volutions of the spire moderately convex with numerous longitudinal, somewhat inclined, rounded ribs and only faintly visible spiral sculpture. The body-whorl shows both axial and spiral sculpture and is cancellated. The expanded outer lip bears a distinct, rounded keel, curved posteriorly into the sharp tip of the wing. The suture of the body whorl near the outer lip extends posteriorly across the preceding whorl but there is no clear evidence in the specimen of a posterior extension of the lip along the spire.

The writer knows no American species very close to *Anchura? forresteri* and though the type is somewhat indefinite believes it worthy of a name. It is best characterized by the size, the form of the extension of the outer lip, and the sculpture. It is strikingly like *Aporrhais* ("*Chenopus*") *olisiponensis* Choffat[13] from the lower Turonian of Portugal, though on the basis of the single specimen available it seems better to keep the two under separate names. It is difficult to tell from either Choffat's figures or the present specimen whether the two species belong to *Anchura* or *Aporrhais*, though they are in some respects more like certain species definitely assignable to *Anchura*.

The type is in the U. S. National Museum (Cat. No. 73459).

ILLUSTRATIONS

Figures 1–6. *Ostrea gillulyi* Reeside, n. sp., outer, inner and anterior views of the two valves of the type, a complete shell from the Fox Hills sandstone in the NW 1/4 sec. 7, T. 9 N., R. 67 W., Weld County, Colorado. (p. 308.)

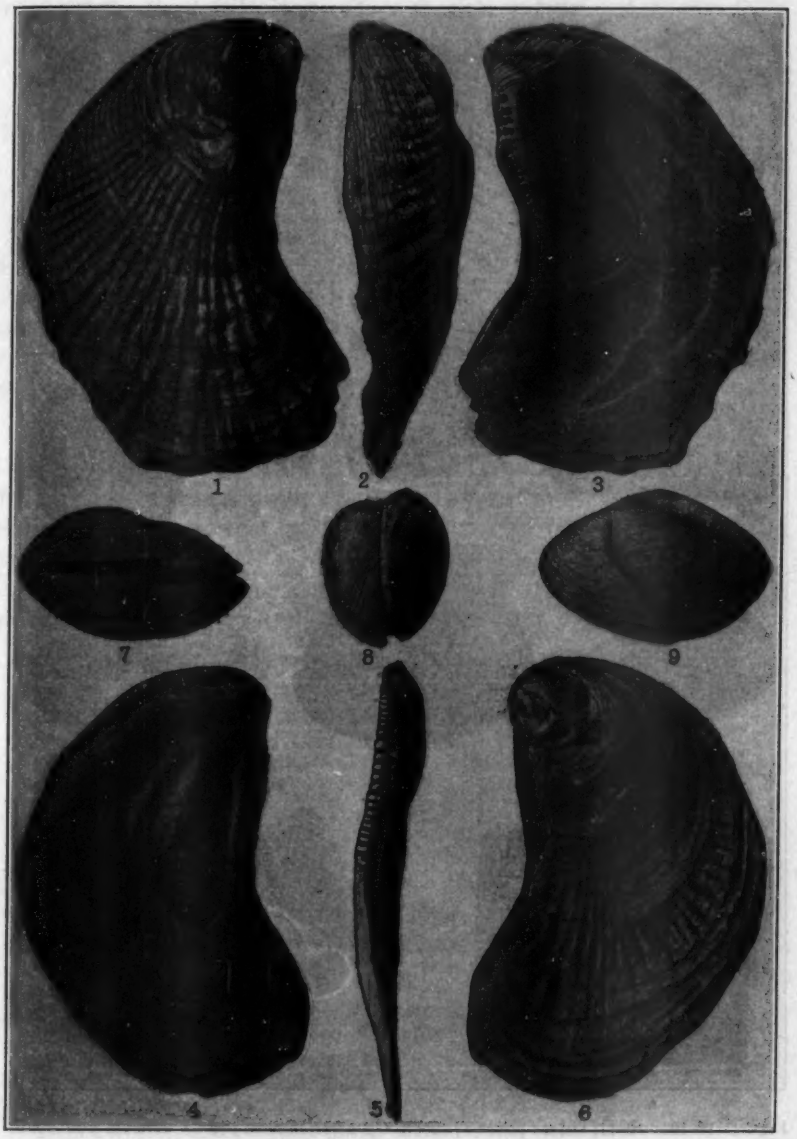
Figures 7–9. *Nucula larimerensis* Reeside, n. sp., basal, anterior, and right views of the type, a complete shell from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado. (p. 306.)

Figure 10. *Ostrea gillulyi* Reeside, n. sp., a left valve with strong radial sculpture. Same locality as Figs. 1–6. (p. 308.)

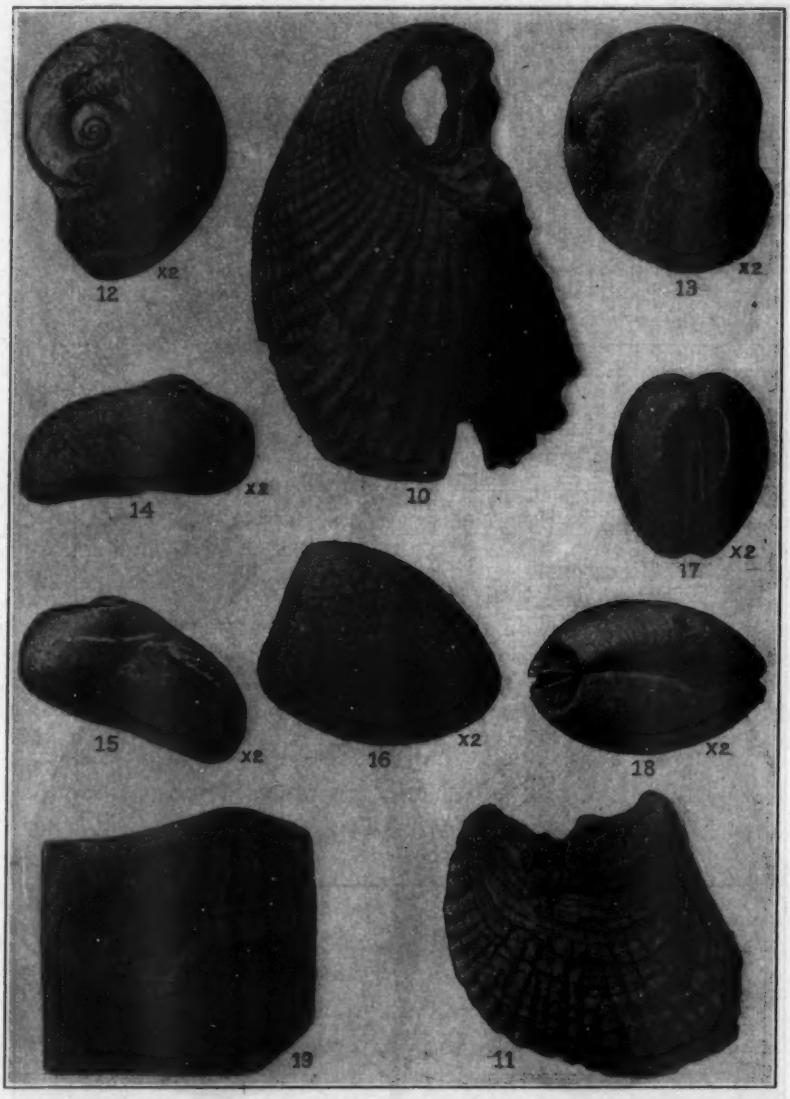
Figure 11. *Ostrea gillulyi* Reeside, n. sp., a left valve with strong concentric sculpture. Same locality as Figs. 7–9. (p. 308.)

Figures 12–15. *Gyrodes johnsoni* Reeside, n. sp., apical, umbilical, dorsal, and apertural views (×2) of the type, a cast retaining parts of the shell. Same locality as Figs. 7–9. (p. 309.)

[13] PAUL CHOFFAT. *Faune crétacique du Portugal* 1(1): 12. *Prosobranches pl. 2, f. 8–9.* 1886; 1(4). *Prosobranches pl. 5, f. 1–2.* 1902.



Figures 1–9. 1–6, *Ostrea gillulyi*; 7–9, *Nucula larimerensis*



Figures 10–19. 10–11, *Ostrea gillulyi;* 12–15, *Gyrodes johnsoni;* 16–18, *Nucula weldensis:* 19, *Anchura? forresteri*

Figures 16–18. *Nucula weldensis* Reeside, n. sp., right, posterior, and top views (×2) of the type, a complete shell. Same locality as Figs. 7–9. (p. 307.)

Figure 19. *Anchura? forresteri* Reeside, n. sp., plaster cast from the type, a mould from the basal part of the beds of Colorado age at Black Bluff, Utah. (p. 310.)

RADIOGEOLOGY.—*The radium content of Stone Mountain granite.*[1]

CHARLES SNOWDEN PIGGOT, Geophysical Laboratory, Carnegie Institution of Washington.

This paper refers to the first measurements by the author, of what is intended to be a comprehensive study of the radium content of the various classes of rocks of the Earth's structure. It is of a preliminary and introductory nature only. A paper describing in detail the apparatus and technique used and the results obtained from a study of several rocks will be published shortly.

DESCRIPTIVE

The sample used was a gray biotite-muscovite granite from Stone Mountain, Georgia, and was a part of the same block as used by Day, Sosman and Hostetter[2] in their determination of densities at high temperatures.

The density of this material at 25° is 2.633 and the chemical composition as determined by Packard[3] is as follows:

ANALYSIS, NORM, AND MODE OF STONE MOUNTAIN GRANITE

SiO_2	71.66
Al_2O_3	16.05
Fe_2O_3	0.86
FeO	Not determined
MgO	0.17
CaO	1.07
Na_2O	4.66
K_2O	4.92
H_2O+	1.00

NORM[3]		MODE[4]	
Quartz	22.80	Quartz	20
Orthoclase	28.91	Microcline	40
Albite	39.30	Plagioclase $Ab_{85}An_{15}$	30
Anorthite	5.28	Mica, nearly all muscovite	10
Corundum	1.12		
Hypersthene	1.72		

[1] Received March 14, 1928.

[2] ARTHUR L. DAY, R. B. SOSMAN and J. C. HOSTETTER. Am. Journ. Sci. **37**: 1–30. 1914. Also Neues Jahrb. Beil. Bd. **40**: 119–162. 1915.

[3] H. S. WASHINGTON. *Chemical analyses of igneous rocks.* U. S. Geol. Survey, Prof. Paper **99**: Analysis No. 51, p. 173. 1917.

[4] L. H. ADAMS and E. D. WILLIAMSON. *The compressibility of minerals and rocks at high pressures.* Journ. Frank. Inst. **195**: 483. 1923.

The rock was crushed, and ground to a fine powder in a ball mill. A 25-gram sample was mixed with 100 grams of a flux, consisting of equal parts by weight of anhydrous sodium and potassium carbonates, and the mixture was fused in a furnace of special design, in a slow stream of pure carbon dioxide gas. Any radium and thorium emanation was carried out of the melt by the carbon dioxide produced by the fusion and was swept along in the stream of CO_2. This latter was absorbed by hot sodium hydroxide solution, and the unabsorbed gases, consisting of air (adsorbed on the mix), helium, and minute quantities of other gases from the rock, and containing the radium and thorium emanations, were collected over mercury, which was regulated by a leveling bulb. From there they were subsequently drawn into an evacuated emanation chamber and the remaining vacuum relieved by drawing CO_2-free air through the entire apparatus and thereby insuring the assembly of all emanation within the emanation chamber.

This chamber[5] is a closed cylinder of brass of one liter capacity with a brass rod projecting down the center through insulation of pure amber. After allowing the chamber to stand under a static charge of 650 volts potential difference for three hours, to permit of the elimination of any thorium emanation, an alpha-ray determination was made in the usual way with a gold-leaf electroscope of the detachable Lind type.[5]

Calibration was effected by making a number of runs with the granite alone, and then making another series, identical in every respect except that a known amount of radium, in equilibrium with its disintegration products, was added.

This added radium was secured by pipetting a standard radium solution into small thin-walled glass bulbs, evaporating slowly to dryness and then sealing the bulbs. These were allowed to stand for more than thirty days, after which time the radium was again in equilibrium with its emanation, and the bulbs could be used. Bulbs containing 1 and 3 cubic centimeters of solution, respectively, were used. A bulb would be embedded in the mix and the fusion carried out in the usual way.

The standard radium solution used was such that 1 cubic centimeter contained 32.2×10^{-12} grams radium element.

The flux alone was found to have some radioactivity. That this

[5] A development of the detachable electroscope and chamber of S. C. Lind. Vide, Bull. 212, Bureau of Mines. Also Journ. Ind. and Eng. Chem. 7: 406. 1915; 7: 1024–29; 12: 469–72. 1920.

was a true effect is indicated by the fact that a run made on 100 grams of flux gave an electroscope reading of 0.0014 divisions per second, while a 200-gram sample of the same material gave a reading of 0.0029 divisions. A number of runs were made which confirmed these figures.

The "natural leak" of the electroscope assembly was always taken before each measurement and applied as a subtractive correction to all readings. In every case the apparatus remained under charge long enough for the insulation to take up any "electrical soak" and come to a condition of stable equilibrium. After each measurement the emanation chamber was blown out for several hours with dry, CO_2-free air drawn from outside the laboratory building.

Experimental

The effect on the electroscope of the granite alone was determined by a series of sixteen fusions, the results constituting the following table. The numbers represent divisions of the scale, as seen in the telescope, which were passed over, per second, by the gold leaf of the electroscope.

No.	*Divisions per second*	*No.*	*Divisions per second*
1	0.0100	9	0.0115
2	.0110	10	.0096
3	.0100	11	.0119
4	.0133	12	.0102
5	.0106	13	.0093
6	.0127	14	.0127
7	.0102	15	.0097
8	.0111	16	.0105

These give an average of 0.01089. If the effect of the flux (0.0014) is subtracted from this the reading for the granite alone is 0.0095.

The addition of a 1-cubic-centimeter bulb of radium to an otherwise normal run produced the following effect:

	0.0137	divisions per second
	.0137	" " "
	.0131	" " "
Average	.01350	" " "
Less the effect of the flux and rock	.01089	" " "
1 cc. Ra solution	.00261	" " "

On adding a 3-cubic-centimeter bulb to a normal run the readings were:

	0.0179	divisions	per	second
	.0176	"	"	"
	.0197	"	"	"
	.0197	"	"	"
	.0179	"	"	"
Average	.01856	"	"	"
Less the effect of the flux and rock	.01089	"	"	"
3 cc. Ra solution	.00767	"	"	"

One-third of which is 0.00256 divisions per second.

The average effect of 1 cubic centimeter of standard radium solution as obtained from the two series of experiments is therefore 0.00259.

Since 1 cubic centimeter of radium solution is equivalent to 32.2×10^{-12} grams radium element, 0.00259 divisions per second fall of the electroscope leaf is equivalent to 32.2×10^{-12} grams, or

$$1 \text{ div. per second} = \frac{32.2 \times 10^{-12}}{0.00259} = 12702 \times 10^{-12} \text{ grams Ra.}$$

So that:

$$\frac{\text{Electroscope reading} \times 12702}{25} = \text{grams} \times 10^{-12} \text{ of Ra per gram rock.}$$

Conclusion

According to the experiments described above the sixteen measurements of the radium content of Stone Mountain granite vary from a low of 4.013×10^{-12} to a high of 6.757×10^{-12}; with an average for the series of 4.826×10^{-12} grams of radium per gram of granite.

BOTANY.—*A new tree fern from Haiti.*[1] William R. Maxon, U. S. National Museum.

Among a number of critical pteridophyta from Haiti recently submitted to the writer by Dr. Carl Christensen for identification is the following undescribed tree fern:

Hemitelia minuscula Maxon, sp. nov.

Fronds small, about 1 meter long, spreading, the stipe (incomplete) about 30 cm. long, slender, arcuate, pale buff from a darker, finely brownish-fur-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 21, 1928.

furaceous base, freely aculeate, the spines narrowly conical, blunt, nearly straight, 1.5–2 mm. long; scales not collected. Blade of an oblong-ovate type, about 70 cm. long, 35 cm. broad, bipinnate-pinnatifid, the rachis pale buff, 3–5 mm. thick, minutely subfurfuraceous above, glabrate beneath, unarmed; pinnae alternate, spreading or slightly decurved, oblong, abruptly short-acuminate, about 18 cm. long, 8–10 cm. broad, short-stalked, the distal basal pinnule distant 5–8 mm. from primary rachis, the proximal one as much as 1.5 cm.; secondary rachis densely substrigose above with curved yellowish-gray hairs, subpersistently paleaceous beneath, the scales pale rufous-brown, thin, lustrous, minute, deeply bullate, mostly with an attenuate flexuous tip (hairs wanting); pinnules 13–15 pairs, spreading (the basal ones often decurved or reflexed), nearly sessile (stalked about 1 mm.), narrowly oblong, 4–5 cm. long, 9–12 mm. broad, attenuate in the outer third, pinnatisect at base, pinnatifid beyond to 0.5–1 mm. from the costa, obliquely crenate at the subcaudate apex, the costa clothed like the secondary rachis; segments 10–12 pairs, oblong, 3 mm. broad at base, slightly curved, rounded-obtuse, rather close, the strongly revolute margins lightly crenate, the costule sometimes with 1 or 2 short weak hairs above, beneath conspicuously bullate-paleaceous throughout; veins 5 or 6 pairs, impressed above, forked just below the middle; sori 5 or 6 pairs, the receptacle strongly elevated, subcapitate, freely septate-paraphysate; indusium a minute, delicately membranous, rufous proximal scale, incised, the divisions lacerate. Leaf tissue thick-herbaceous, dull yellowish-green, discoloring, glabrous.

Type in the Copenhagen Botanical Museum, from Massif du Nord, Anse-à-Toleur, Morne Colombeau, Haiti, alt. 900 meters, June 20, 1925, *E. L. Ekman* H 4365; co-type in the U. S. National Herbarium.

The present species is referable technically to the genus *Hemitelia* because of the presence of a proximal indusial scale, which, though small, is only partially concealed and on account of its divided or deeply cleft form approaches the usual condition found in *Eu-hemitelia*. Of the West Indian tree ferns *H. minuscula* resembles in a general way *Alsophila aquilina* Christ, but that species differs rather widely in its strongly coriaceous leaf tissue, its conspicuously stalked pinnae and pinnules, its non-furfuraceous vascular parts, and its very few, larger, and widely scattered bullate scales of the under surfaces, these usually solitary on the costules. A very minute vestigial indusium scale is usually present in *A. aquilina*, as in a few other species of *Alsophila*, but it is dark colored, distinctly chitinous, closely appressed, and subentire, wholly lacking the filamentous processes seen in *H. minuscula* and several other *Eu-hemitelia* species of tropical America.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES.

THE ACADEMY

211TH MEETING

The 211th meeting, the 29th Annual Meeting, was held in the lecture room, East Building, of the Bureau of Standards on Tuesday, January 11, 1927, with President BURGESS in the chair. President Burgess gave a brief talk illustrated by lantern slides descriptive of various phases of work of the Bureau of Standards. This was followed by an intermission during which guests of the ACADEMY left the room to begin an inspection of the laboratories. After this the annual business meeting was held. It was voted to dispense with the reading of the minutes of the 28th Annual Meeting.

The Corresponding Secretary, F. B. SILSBEE, reported briefly on the activites of the ACADEMY during 1926. His report showed that 20 regular members and one honorary member had been elected and had qualified during the year, 4 had resigned, and 9 had died, showing a net gain of 8. Those who died were: G. N. ACKER, F. H. BIGELOW, C. K. WEAD, F. C. CUMMING, E. W. SAFFORD, C. V. PIPER, W. T. LEE, C. W. ELIOT, F. H. KNOWLTON. The report was ordered accepted and filed.

The report of the Recording Secretary, W. D. LAMBERT, was read. There were held during the year several public meetings, all of them jointly with one or more affiliated societies. The names of the affiliated societies, speakers, and the details of the addresses, and additional items of interest were given. The report was ordered accepted and filed.

The report of the Treasurer, R. L. FARIS, was read. It showed total receipts, $5,647.27; total disbursements, $6,094.72; academy's investments, $18,000.37; cash on hand, $2,208.73; estimated net worth, $20,433.32.

The report of the Auditing Committee, Messrs. AVERS, WHERRY, and PEFFER was read, verifying the Treasurer's figures. The reports of the Treasurer and the Auditing Committee were then accepted.

The report of the Editors of the Journal was presented by AGNES CHASE. It detailed the distribution of the articles in the various fields of science and gave statistics concerning Volume No. 16 of the Journal. The report was ordered accepted and filed.

The report of the Committee of Tellers, Messrs. SILSBEE, GARDNER, and LOMBARD, was presented by the Chairman. In accordance with the report the following officers were declared elected: *President*, A. WETMORE; *Corresponding Secretary*, L. B. TUCKERMAN; *Recording Secretary*, W. D. LAMBERT; *Treasurer*, R. L. FARIS; *Non-resident Vice-Presidents*, T. LYMAN, H. F. PITTIER; *Managers*, R. S. BASSLER; F. B. SILSBEE.

The following Vice-Presidents nominated by the affiliated societies were then elected: *Archaeological*, WALTER HOUGH; *Bacteriological*, W. D. BIGELOW; *Biological*, H. C. OBERHOLSER; *Chemical*, F. T. WHERRY; *Entomological*, A. G. BÖVING; *Geographic*, F. V. COVILLE; *Geological*, N. H. DARTON; *Helminthological*, M. C. HALL; *Historical*, A. C. CLARK; *Mechanical Engineers*, H. L. WHITTEMORE; *Philosophical*, J. P. AULT.

The meeting adjourned at 9.15 and was followed by an inspection of the laboratories in the East and Industrial Buildings at the Bureau of Standards and a social hour.

212TH MEETING

The 212th meeting, a joint meeting with the Philosophical Society, was held on Thursday, February 17, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. ARTHUR HAAS, of the University of Vienna, *The atom as a source of energy.* The Bohr theory of the atom was first discussed and attention called to the enormous amount of energy available both in the planetary system of the atom and in the nucleus. The possibility was presented that by collision of electrons and protons matter might be entirely transformed into energy. The reverse phenomenon, the generation of matter out of radiation, would only be possible for rays of a very high frequency. This frequency ought at least to be so high that one light-quantum of the rays would possess the same amount of energy as would be liberated by the annihilation of a single hydrogen atom. One possible way in which it could occur seems to be suggested by the Compton effect. If atoms or nuclei colliding with light-quanta were in enormously rapid motion, the frequency could be raised in a considerable degree. Collisions with rapidly moving material particles thus might impart to a light-quantum that critical frequency which qualifies it for a transmutation into a hydrogen atom. (*Author's abstract.*)

213TH MEETING

The 213th meeting, a joint meeting with the Anthropological Society, was held on Thursday, February 24, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. ALFRED V. KIDDER, Chairman of the Division of Anthropology and Psychology of the National Research Council, *The Cliff Dwellers of Arizona and their predecessors.* The Southwestern archaeological field embraces those parts of Arizona, New Mexico, Colorado, and Utah, which contain the remains of the sedentary, agricultural type of Indian, commonly known as Pueblos. The present range of the Pueblo Indians is restricted to the drainage of the Rio Grande and the Little Colorado. Ruins of ancient villages closely similar to those of the historic Pueblos are found throughout an infinitely greater range. They consist of cliff houses, valley towns, and mesa-top dwellings, ranging in size from a half dozen to a thousand rooms.

The problem of Southwestern archaeology is the arrangement of these ruins in relative chronological order and the determination of the origin and growth of the culture responsible for them. Until about fifteen years ago the early stages of Pueblo civilization were not recognized. The explorations of the Peabody Museum of Harvard, the Natural History Museum of New York, the National Geographic Society, and other institutions have resulted in the discovery and description of these early stages, the first being the Basket-maker, a phase marked by primitive agriculture, lack of pottery and of stone architecture. This was followed by the post-Basket-maker period which saw the introduction of pottery and the beginnings of masonry construction. The post-Basket-maker was succeeded by the pre-Pueblo, in which pottery was greatly improved, houses were enlarged and strengthened, and the typical massed type of dwelling first introduced. We are thus now in possession of the outline of the entire growth of the Pueblos from nomadism up. (*Author's abstract.*)

214TH MEETING

The 214th meeting, a joint meeting with the American Chemical Society (Washington Section) and the American Society for Steel Treating (Washington-Baltimore Section), was held on Friday, March 4, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. CECIL DESCH, of the University of Sheffield, *The growth of crystals.* (Given in full in a paper entitled *The growth of metallic crystals* presented at a meeting of the American Institute of Mining and Metallurgical Engineers in February, 1927 and published in the proceedings of that Institute.) Geometrical crystallography, which has reached a state of such remarkable perfection since its beginnings a century and a half ago, is concerned with the conditions of symmetry in crystals and with their possible faces, but it attaches little importance to the relative development of those faces, so that variations of habit, of such interest to the mineralogist, are mostly ignored. Since crystals of strikingly different habit, such as the many varieties of calcite, may all be derived from the same primitive crystal, their peculiarities must be due to variations in the conditions during growth, and this fact gives to the study of the growth of crystals a special importance. A simple crystal immersed in a solution of the right degree of supersaturation may continue to grow whilst retaining its original shape unimpaired, as in the perfect octahedra of the alums which have been prepared by some manufacturing firms. Such crystals may grow to a large size without change of shape, and when an octahedron of chrome alum, for instance, is allowed to grow in a solution of the isomorphous common alum, the regularity of growth is obvious from the uniformity of the colourless sheath enveloping the coloured nucleus. The increase in size has been brought about by the deposition of a uniform layer of new material on each face. On the other hand, faces may disappear or new faces may make their appearance in the course of growth, and an explanation has to be sought in the external conditions and in the internal structure of the crystal, both factors being concerned in producing the result.

It has long been known, certainly since the eighteenth century, that the presence of small quantities of foreign matter will sometimes produce a change of crystalline form. Common salt, which usually crystallises in cubes, forms octahedra if grown in a solution containing urea. When the quantity of urea is small, crystals with the faces of both the cube and the octahedron are produced. The crystals of organic compounds often vary very greatly according to the solvent which has been used. Such facts as these give the first clue to the problem of growth.

The use of X-rays in the study of crystal structure has placed crystallography on an entirely new footing. All modern studies of crystals start from the idea of the space lattice. The atoms, whether occurring singly or grouped to form molecules, are so arranged in space that a single unit is exactly repeated at regular intervals in three dimensions. Through such an assemblage planes may be drawn in any direction. Certain planes so drawn will contain a greater number of atoms in a given area than any planes drawn in a different direction, and it is these closely packed planes which play the principal part in crystal structure. Moreover, in crystals in which the atoms are of more than one kind, different planes may contain the atoms in different relative proportions, so that they may be assumed not to be chemically identical. Any plane may be imagined as a possible face of the crystal, although only a few of them are realisable in practice. The several planes

must have different chemical properties. This follows from our conception of the space lattice. The forces which hold the atoms in position are electrical in character, and depend on the number and arrangement of the electrons in each atom. The chemical behavior is dependent on the same conditions, and the chemical properties of a crystalline surface must vary with the grouping of the atoms within it. What chemists often call residual affinity must vary with the denseness of packing of the atoms in a plane, so that each set of similar faces must have its own chemical characteristics. This supposition is confirmed by the action of chemical agents on crystals. In the etching of metals by acids, it is easily seen that the reagent penetrates more readily along certain planes than in any other direction, as clear facets, of cubes or octahedra in most instances, make their appearance and give the characteristic lustre to the etched surface.

It has been shown by Johnsen, Gross and others that the faces which survive during growth are those which have the lowest velocity of growth in a normal direction, and that these are in general the most closely packed planes. More openly packed planes have a higher velocity of growth, but their relative area diminishes as the crystal increases in size, and they ultimately disappear. The experiments of Nacken on salol and benzophenone are instructive. By attaching a small crystal of salol to a copper hemisphere immersed in the molten substance maintained at a constant temperature, and withdrawing heat by cooling a copper rod attached to the hemisphere, the rate of cooling could be varied, and it was found that when this was very slow, the liberation of latent heat by the solidification of the salol and its removal by conduction kept pace with one another, and the surface of the growing crystal was spherical or nearly so, being determined only by the thermal conductivity, which varies only slightly in the direction of the different crystallographic axes. As the rate of cooling is increased, the growth perpendicular to certain directions fails to keep pace with the rest, and faces having a low velocity of perpendicular growth begin to make their appearance, at first with oval outlines. As the crystal increases in size, the area of such faces increases until their boundaries meet, and the crystal at last assumes its typical form, with plane faces and straight edges.

The experiments of Volmer and others on the formation of crystals of zinc and mercury in an evacuated vessel, by the impact of a stream of molecules of the metal on a plane surface, have thrown much light on the process. Nuclei are at first formed, and those grow which have the basal plane (the crystals being hexagonal) perpendicular to the direction of the stream. This plane has the lowest velocity of growth in a direction normal to itself. With mercury at $-60°$C thin leaflets result, the thickness of which is only one ten-thousandth of the diameter. A quantitative interpretation of these experiments, together with those of Marcelin, which proved growth to be a discontinuous process, occurring by the formation of successive thin sheets, leads to the conclusion that atoms or molecules are first adsorbed as a layer of unit thickness, the atoms or molecules in which have a certain freedom of movement. In the course of such movement, groupings which may be regarded as two-dimensional crystal nuclei may arise, and the whole layer then assumes an orderly arrangement, in conformity with the underlying space lattice. Since adsorption plays so large a part in growth, it is not surprising that an alteration of habit may be produced by the presence of impurities. The observations of Gaubert on lead nitrate are particularly instructive. This salt separates from water in octahedra, but when methylene blue is added

cubic faces appear, these faces being stained blue while the octahedral faces remain colourless. As the quantity of the dye is increased, the crystals become completely cubic, with blue faces. Evidently adsorption of the colouring matter by the cube face has lessened its rate of growth, so that it survives at the expense of the more rapidly growing octahedral face. It is probable that differences of habit in naturally occurring minerals are largely due to the influence of small quantities of foreign matter, but a very small quantity may suffice, so that the impurity responsible for the result may not have been detected in the course of an analysis.

Well developed crystals are usually formed by comparatively slow growth, so that as material is withdrawn from the solution, or as heat is given out by the solidification of a melt, there is ample time for readjustment. Miers has shown that the solution in immediate contact with the growing face of a crystal of a salt is actually denser than the bulk of the solution, suggesting that the dissolved molecules undergo a preliminary rearrangement in the liquid before separation as a solid. For this view there is some evidence, notably from the fact, observed by Nasini and others, that solutions which are undercooled through the freezing point show small discontinuities in properties, although no solid separates. It will be of interest to examine this point by means of the X-ray method. On the other hand, when growth is very rapid, the supply of material by diffusion may not keep pace with it, and the conditions are disturbed. Simple geometrical considerations show that the sharp angles of the crystal are more favourably placed for the reception of material by diffusion than the middle parts of faces, so that growth occurs at the angles by preference. The effect is cumulative, so that the crystal assumes a star shape, which in course of time undergoes branching, the process being repeated at each branch. This is the origin of dendritic crystals, which are so common in nature. They are most easily obtained by allowing crystallisation to take place rapidly, as when a solution of a salt is evaporated quickly on a glass slide. The internal symmetry of the crystal is not destroyed, and most such crystals may be regarded as parallel growths, one axis being usually favoured. Thus native copper branches in the direction of the octahedral axis, whilst common salt forms growths parallel with the trigonal axes. Diffusion may be hindered, and dendritic growth encouraged, by making the solution more viscous, as by adding gum. In highly viscous materials, such as glasses, slags, and pitchstones, very beautiful dendritic growths are frequently present. The "trees" formed by the electrolysis of solutions of metallic salts have a similar structure.

Periodic crystallisation is an interesting phenomenon, which again has a bearing on the origin of naturally occurring mineral structures. It was observed more than 70 years ago by Brewster in ancient glass which had undergone a process of decay. It may arise from several different causes in different substances. The effect is very simply observed in molten salol. When a thin layer is melted on a slide and allowed to cool, slender needles are seen to radiate from each centre. The advancing point of each needle withdraws material from the liquid, and a gap is left, the molten salol standing up as a wall in front of the crystal edge. Owing to its viscosity, an appreciable time is required for the liquid to flow until it is again in contact with the crystal, when growth is resumed. This process is repeated, so that the advance of the needle is intermittent, and the crystal when complete is marked by transverse lines indicating the stages of growth. The process may be followed under the microscope with ease. Some salts crystallise

from water with a very definite periodicity, the best example being potassium dichromate, a thin layer of a solution of which, if rapidly evaporated, will yield concentric rings of minute crystals with very regular intervals. The effect is here no doubt one of supersaturation, the solution being impoverished by the separation of one ring of crystals, so that the process is interrupted until the right concentration is again reached by diffusion, and so on. Similar structures are seen in glazes on porcelain and, although more rarely, in slags. They are closely connected with the phenomenon of periodic precipitation in jellies, the formation of Liesegang's rings. The study of periodic crystallisation throws light on some natural structures, especially of agates, which are in all probability formed by the periodic crystallisation of silica from the gelatinous contents of a cavity in a rock. Ruskin maintained that the banding in agates was due, not to periodic infiltration of a liquid, but to segregation, and his view is confirmed by modern work. In particular, the so-called canals which have been supposed to represent the passages by which liquid entered and left the cavity are seen, by laboratory experiments on periodic crystallisation, to be merely geometrical effects produced by the meeting of different systems of advancing bands.

Dendritic and periodic crystallisation depend on more complex causes than change of habit, and are correspondingly more difficult to study in a quantitative manner, but there can be little doubt that the examination of the chemical properties of the several planes in crystals will throw much light on these as on other problems of crystallisation. (*Author's abstract.*)

215TH MEETING

The 215th meeting, a joint meeting with the Anthropological Society, was held on Thursday, April 21, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. FREDERICK W. HODGE, *The Zuñi Indians of New Mexico.* (Illustrated by lantern slides and moving pictures.) The speaker reviewed briefly the history of the Zuñi Indians during the Spanish regime, commencing with the year 1539, when their pueblos first became known to civilization as the "Seven Cities of Cibola." A glimpse of Zuñiland, together with views of the salt-gathering ceremony at the sacred Salt Lake, was offered in motion-pictures. Other pictures illustrated the process of pottery-making from the preparation of the clay, through the fashioning and painting of water-jars and food-bowls, to the finished receptacles. The grinding of corn and the manufacture of wafer-bread, one of the most ancient and still the most important food staple of Zuñi, was illustrated as further showing a part of the domestic life of a people whose primitive customs have been little changed.

Still retaining most of their ceremonies of old, the Zuñi perform rites at their sacred Rainbow Spring for the purpose of bringing rain, the ceremony shown in the picture being in the native belief the direct cause of the first showers for nine months. Following this rite, on the next day, a masked rain-dance was performed at the main pueblo of Zuñi, views of which, showing the dance-steps and the costumes of the participants, together with the antics of the "mud-head" clowns, were presented as affording an impression of religious ceremonies that probably have been practised unaltered for many centuries. (*From notes supplied by the speaker.*)

W. D. LAMBERT, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

PAUL C. STANDLEY, formerly of the U. S. National Museum, has been appointed Associate Curator of the Herbarium in Field Museum of Natural History, Chicago. He began work in his new position the first of June.

Dr. E. O. ULRICH, of the U. S. Geological Survey, is spending four weeks in May and June in field work in Missouri, Arkansas, and Oklahoma. Dr. T. W. STANTON, will spend the latter half of June and the month of July in a continuance of his studies on the Cretaceous of western Texas. Drs. EDWIN KIRK and G. H. GIRTY will spend several months in examination of the Paleozoic rocks of the Eureka district and other parts of Nevada. Dr. JOHN B. REESIDE, JR., will visit Geological Survey parties in connection with work on the Mesozoic formations of the Rocky Mountain region.

Dr. JULIA GARDNER is spending the summer in Louisiana and Texas in a continuation of her studies on the Tertiary formations of the Gulf Coastal region.

Professor A. S. HITCHCOCK, of the Bureau of Plant Industry, and Custodian of Grasses in the U. S. National Herbarium, has left Washington for a collecting trip to Newfoundland. He will first visit the New York Botanical Garden and the Gray Herbarium of Harvard University to study the grass collections of these institutions. The months of July and August will be spent in Newfoundland and Labrador studying and collecting grasses. Many species of grasses have been described from Newfoundland the identity of which is uncertain. It is hoped that some of these species may be found. The work is in connection with the preparation of a Manual of the grasses of the United States.

To select a successor to Dr. FEWKES recently retired from the position of Chief of the Bureau of American Ethnology, Smithsonian Institution, a special board of examiners, composed of Secretary Abbot, Dr. A. V. Kidder, Carnegie Institution, and Frederick W. Brown, Assistant Chief of the Examining Division of the U. S. Civil Service Commission has been formed, in view of the importance of the position. The examination will consist solely of the consideration of qualifications by the special board. The minimum qualifications are recognized eminence in American ethnological research, experience in the direction and prosecution of ethnological research, administrative capacity, and familiarity with the literature of American ethnology and archaeology, and with the activities of scientific and professional organizations and institutions concerned with the subject.